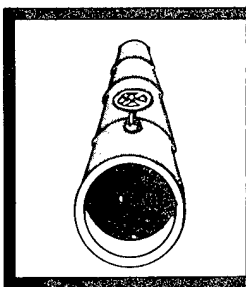
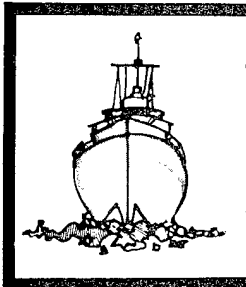
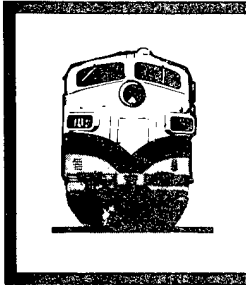
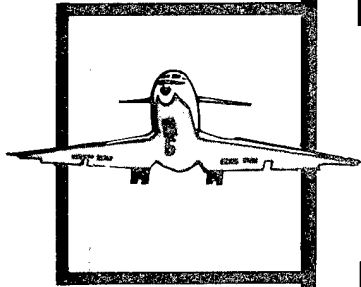


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NATIONAL TRANSPORTATION SAFETY BOARD

DTIC QUALITY INSPECTED 2

WASHINGTON, D.C. 20594

MARINE ACCIDENT REPORT

**RAMMING OF THE
POPLAR STREET BRIDGE
BY THE TOWBOAT M/V CITY OF GREENVILLE
AND ITS FOUR-BARGE TOW
ST. LOUIS, MISSOURI
APRIL 2, 1983**

NTSB/MAR-83/10

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15. Supplementary Notes			
<p>16. Abstract</p> <p>About 2320 c.s.t. on April 2, 1983, a tow consisting of four single-hull tank barges, being pushed by the towboat CITY OF GREENVILLE, collided with one of the piers of the Poplar Street Bridge, which crosses the Mississippi River between St. Louis, Missouri, and East St. Louis, Illinois. At least one of the two middle barges in the tow was ruptured by the impact of the collision. Crude oil was released and ignited almost immediately. Three barges broke loose and floated downriver. One barge sank about 1 mile from the bridge, a second barge collided with barges moored at a chemical barge loading facility, and the other barge collided with a grain barge loading terminal. The facilities sustained severe damage. The burning oil ignited several fires along about 2 miles of waterfront on the Illinois side of the river and polluted approximately 10 miles of the river. There were no deaths, and only one person received minor injuries as a result of this accident. The damage to the barge loading facilities, the damage to grain barges and their cargoes, the damage and loss of cargo sustained by the tow of the CITY OF GREENVILLE, and the cost of oil cleanup operations were estimated to be about \$9 million.</p> <p>The National Transportation Safety Board determines that the probable cause of the accident was the failure of the operator of the towboat CITY OF GREENVILLE to identify the main navigation span of the Poplar Street Bridge in time to align his tow for passage through the span.</p>			
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**NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594**

MARINE ACCIDENT REPORT

Adopted: November 29, 1983

**RAMMING OF THE POPLAR STREET BRIDGE
BY THE TOWBOAT M/V CITY OF GREENVILLE
AND ITS FOUR-BARGE TOW
ST. LOUIS, MISSOURI
APRIL 2, 1983**

INTRODUCTION

This accident was investigated jointly by the National Transportation Safety Board and the U.S. Coast Guard. Public hearings were held in St. Louis, Missouri, on April 5, 1983, and in Memphis, Tennessee, on June 9, 1983. This report is based on the information developed by the investigation and analyses made by the Safety Board. The Safety Board has considered all those facts pertinent to the Safety Board's statutory responsibility to determine the cause or probable cause of the accident and to make recommendations. The Safety Board's analyses and recommendations are made independently of the Coast Guard. To inform the public of all Safety Board recommendations and the responses to the recommendations, notices of the recommendations and the responses are published in the Federal Register.

SYNOPSIS

About 2320 c.s.t. on April 2, 1983, a tow consisting of four single-hull tank barges in tandem laden with crude oil, being pushed by the towboat CITY OF GREENVILLE, collided with one of the piers of the Poplar Street Bridge, which crosses the Mississippi River between St. Louis, Missouri, and East St. Louis, Illinois. The tow was proceeding downriver during high water conditions, en route from Wood River, Illinois, to Memphis, Tennessee. At least one of the two middle barges in the tow was ruptured by the impact of the collision. Crude oil was released and ignited almost immediately. One barge remained connected to the towboat, but the other three barges broke loose and floated downriver. One barge sank about 1 mile from the bridge, a second barge collided with barges moored at a Monsanto Chemical Company barge loading facility, and the other barge collided with a Pillsbury Company grain barge loading terminal. The Monsanto and Pillsbury facilities, both located on the Illinois side of the river, sustained severe damage. The burning oil ignited several fires along about 2 miles of waterfront on the Illinois side of the river and polluted approximately 10 miles of the river. There were no deaths, and only one person, who was working on barges at the Monsanto facility, received minor injuries as a result of this accident. The damage to the barge loading facilities, the damage to grain barges and their cargoes, the damage and loss of cargo sustained by the tow of the CITY OF GREENVILLE, and the cost of oil cleanup operations were estimated to be about \$9 million.

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the operator of the towboat CITY OF GREENVILLE to identify the main navigation span of the Poplar Street Bridge in time to align his tow for passage through the span.

INVESTIGATION

The Accident

On April 1, 1983, at about 2320, 1/ the towboat M/V CITY OF GREENVILLE, pushing a tow consisting of four tank barges, arrived at the Marathon Pipeline Company Dock at Wood River, Illinois (mile 196.6, Upper Mississippi River (UMR)), 2/ to load a cargo of Montana crude oil. After loading about 65,000 barrels of crude oil, distributed among the four barges to bring each barge to a 9-foot draft, the CITY OF GREENVILLE and its tow got underway at about 2045 on April 2, 1983, en route to the Delta Refining Company in Memphis, Tennessee. The tow, including the towboat, was about 1,045 feet long and 50 feet wide. Prior to getting underway, the operator spoke by telephone with the port captain for Valley Towing Service, Inc., of Memphis, owners of the tow boat and barges, regarding the conditions on the river. The operator had received reports earlier that the river had reached 28 feet and was rising. The port captain advised the operator to be careful, but offered no other information or instructions.

All maneuvers of the rudders and adjustments of engine speeds were being made by the operator. Also in the pilothouse was a steersman who was standing by for the purpose of observing the actions of the operator, the maneuvering characteristics of the tow, and landmarks along the waterway in training for becoming an operator in charge of a watch. The CITY OF GREENVILLE's voyage to Memphis would take it under several bridges, including four bridges between St. Louis, Missouri, and East St. Louis, Illinois, crossing the river within 1.2 miles of each other.

After passing through Lock No. 27 in the Chain of Rocks Canal 3/ (mile 185 UMR), the operator placed the engines at full speed ahead, which resulted in about 8 to 9 mph through the water. After the tow exited the Chain of Rocks Canal at mile 184.1 UMR and was proceeding down the freeflowing river, where the current was about 6 to 7 mph, it was making a speed over the ground of about 15 mph.

The operator maneuvered the tow under the Merchants Bridge (mile 183.2 UMR) and the McKinley Bridge (mile 182.5 UMR) without experiencing any navigation problems despite the high-velocity current conditions associated with the high stage of the river. As the tow approached the Veterans Memorial Bridge (mile 180.2 UMR) and the Eads Bridge (mile 180.0 UMR) in the St. Louis area, the operator maneuvered the tow to pass through the center arch of the Eads Bridge, while attempting to keep the tow aligned with the general axis of the river. The river stage was 29 feet and there was a 6 to 7 mph current. 4/ The operator said that he was aware that a draft, or crosscurrent, could occur near the Eads Bridge, but that he did not know from which direction it might come or the velocity such a current might have and, thus, did not know which direction or how far his tow might be set. However, he stated that he believed the correct way to navigate through the Eads Bridge was to line up on the green lights marking the center of the main span.

1/ All times are central standard time based on a 24-hour clock.

2/ All river miles along the Upper Mississippi River are measured from the confluence of the Ohio and Mississippi Rivers just south of Cairo, Illinois.

3/ The Chain of Rocks Canal, a 12-mile long canal paralleling the freeflowing river from mile 184.1 to mile 194.1, is used to avoid shoaling conditions in the Chain of Rocks section of the river.

4/ The current velocity in St. Louis Harbor typically varies from about 3.5 mph when the river stage is 5 feet on the St. Louis gage to about 5.5 mph when the river stage is 20 feet on the St. Louis gage.

As the tow passed under the closely spaced Veterans and Eads Bridges (see figure 1), the operator recognized that a crosscurrent was setting the tow to the left. At some point the operator applied some amount of left rudder in an attempt to move the stern to the right to prevent the pilothouse or upper parts of the deckhouse of the towboat from striking the left side of the center arch of the Eads Bridge. This application of left rudder moved the stern to the right, causing the head of the tow to move to the left toward the Illinois side of the river. The steersman stated that, as the towboat passed under the Eads Bridge, the towboat was very close to the triangular-shaped mark which indicated the extreme left edge of the usable span of the bridge's center arch. 5/ (See figure 1.)

The operator stated that the tow angled to the left of the river axis and was pointing toward the Illinois side of the river as it cleared the Eads Bridge, but he stated that the curve of the river to the right would cause the tow to point to some extent toward the Illinois side of the river as it passed under the Eads Bridge. The steersman stated that the tow was pointed toward the ramp, or center portion, of the Peabody Coal Company terminal after clearing the bridge. (See figure 1.) About the time that the towboat emerged from beneath the Eads Bridge, the operator saw two green lights on the Poplar Street Bridge (mile 179.2 UMR), which was about 0.8 mile downstream, and he began to steer the tow toward them. 6/ (See figure 1.) The operator stated that he steered a fairly straight course toward the green lights, that he thought the span he was heading for might be the main navigation span, and that the white lights he expected to see above the green lights might be burned out, which he said occasionally happened on other bridges.

Actually, the green lights that the operator was steering toward marked the center of the left side span of the Poplar Street Bridge, 7/ which is adjacent to the Illinois bank, and not the center of the main span. (See figure 1.) When the tow was about midway between the Eads and Poplar Street Bridges, the operator noticed two white lights in a vertical line off the starboard bow of the tow. Shortly thereafter, he also saw that there were two green lights located below the white lights. At this time the operator recognized that the combination of white and green lights indicated the location of the main navigation span. (It was determined subsequently that the upper white light was not illuminated.) However, because he believed that there was not sufficient distance ahead between the tow and the Poplar Street Bridge to permit moving the tow sufficiently to the right to align it for passing through the main span, he continued to steer toward the green lights marking the center of the left side span.

The operator said that, as the head of the tow approached the left side span, he noticed that the tow appeared to be encountering a crosscurrent pushing him away from the Illinois side and that the tow was approaching very close to the right descending pier

5/ In addition to normal bridge lighting, triangular-shaped marks are installed on the center span of the Eads Bridge to indicate the limits of the usable span and to warn vessels of the low steel of the arch.

6/ At night the center of the navigation span of a bridge is indicated by green lights, located on the upstream and downstream sides of the bridge. The bridge piers normally are marked by red lights attached to the piers or to protective fendering and, where the piers are outside the navigable channel, red lights are located on the bridge to mark the limits of the channel. When a bridge has more than one navigation span, the main span normally is indicated by three white lights in a vertical line located above the green lights marking the center of the main span.

7/ The Poplar Street Bridge and adjacent Douglas MacArthur Bridge have three spans. The spans on the right descending bank (Missouri Side) normally are not used for navigation due to the presence of barge fleeting areas and moorings for excursion boats and a floating restaurant.

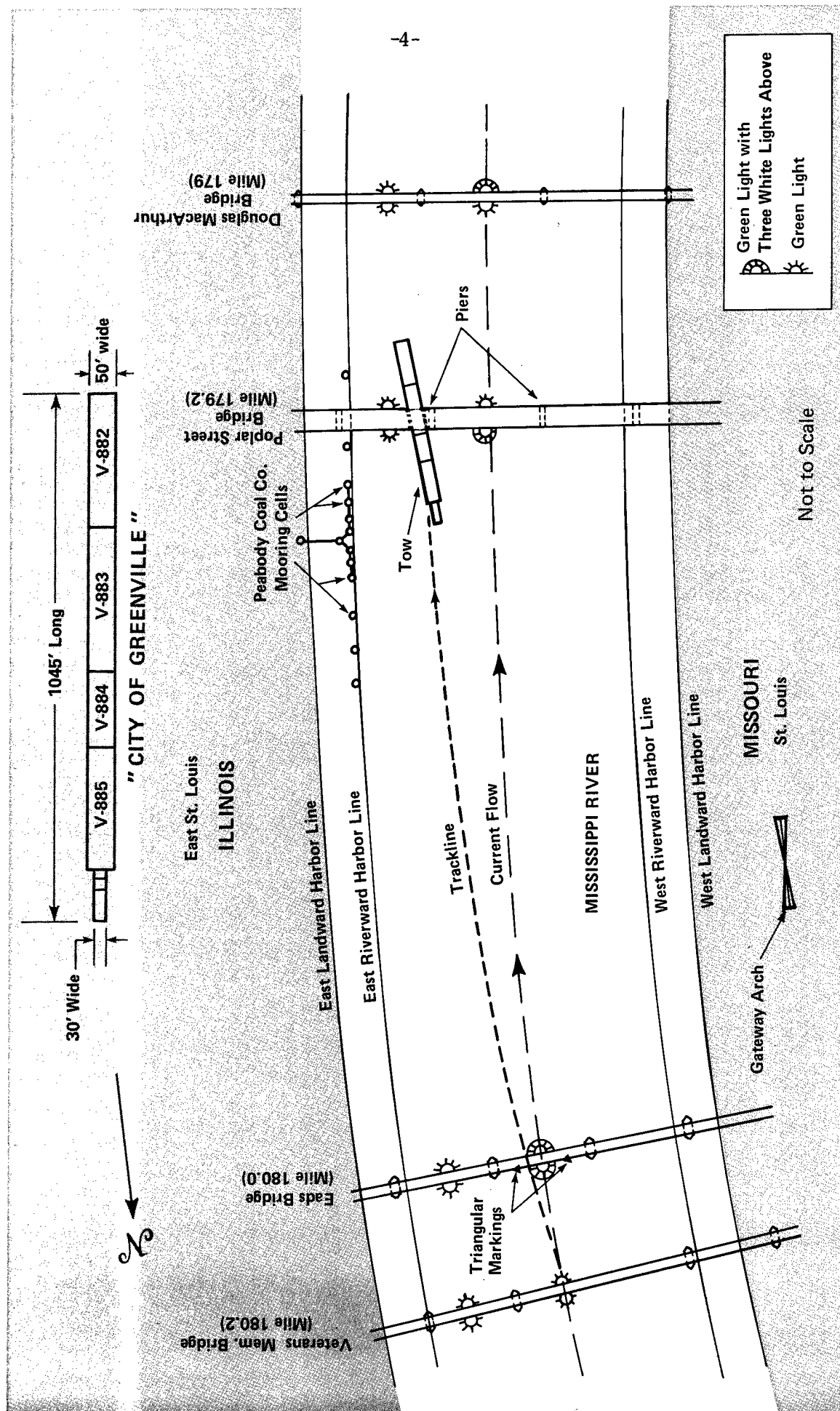


Figure 1.--Approximate trackline of the CITY OF GREENVILLE.

of the left side span. At this time the operator turned on the searchlight and illuminated the pier. This was his first use of the searchlight in navigating through the St. Louis harbor area. By the time the head of the tow entered the left side span, it was apparent that the starboard side of the tow might strike the bridge pier, and the operator applied right rudder in an attempt to move the stern of the tow to the left and away from the pier. This maneuver was not successful, however, and the starboard side of the tow, at about the point where the second and third barges were coupled, struck the right bridge pier of the left side span at about 2320. (See figure 1.)

The force of the impact caused one or both of the two center barges to rupture and spill crude oil into the river. The total cargo lost as a result of the accident was later determined to be about 16,800 barrels. Possibly, over half of this amount was released within a few hours following the collision. The leaking crude oil was ignited almost immediately, producing flames which reached as high as the roadway of the bridge about 70 feet above the water. A considerable amount of burning crude oil reached the Illinois bank of the river where it caused numerous fires.

The first three barges broke loose and floated downstream. One or more of the breakaway barges collided with the right descending pier of the Illinois side span of the Douglas MacArthur Bridge (mile 179 UMR), which was about 0.2 mile downstream. (See figure 1.) Much of the pier was darkened by fire, which either started with the collision of a barge or barges with the bridge or was already in progress on the barge or barges involved. One or more of the breakaway barges collided with barges moored in fleeting areas downstream from the Poplar Street bridge along the Illinois side of the river. One or two of the breakaway barges collided with barges moored at a Monsanto Chemical Company barge unloading facility (mile 178 UMR), fracturing a large chemical pipeline on the pier and releasing a small quantity, estimated at about 100 pounds, of monochlorobenzene ^{8/} into the water. The No. 3 barge in the tow sank just upstream of the Monsanto facility. The No. 2 barge in the tow, which was afire, collided with a Pillsbury Company grain unloading facility (mile 177.6 UMR), also on the Illinois side of the river, and grounded. Grain barges at the Pillsbury facility caught fire, and a large section of the conveyor used to transport grain to the barges was destroyed. The lead barge, which was on fire and leaking considerable oil, eventually was pushed ashore by another towboat, and the fire was extinguished by a Coast Guard cutter.

Immediately after the collision, the operator notified the Coast Guard about the accident on channel 16 and then moored the CITY OF GREENVILLE and its remaining barge at the Peabody Coal Company terminal located on the Illinois side of the river immediately above the Poplar Street Bridge.

A number of commercial vessels in the St. Louis area got underway in order to assist in firefighting and in securing the breakaway barges. The primary firefighting effort was provided by the Coast Guard Cutters OBION, SUMAC, and CHEYENNE. A number of local firefighting units joined in fighting the fires on the shore. All fires were extinguished by about 0700 the next morning, except for fires in several grain barges which smoldered for about a week.

The Captain of the Port of St. Louis, in accordance with the Coast Guard's Local Oil Pollution and Hazardous Material Contingency Plan, established a command center within the Marine Safety Office which was manned on a 24-hour basis. Other Coast Guard

^{8/} Monochlorobenzene is a flammable liquid having a flashpoint of 84° F and an explosive range of 1.3 to 9.6 percent by volume in air. It is toxic by inhalation, skin contact, and ingestion. Exposure to vapors can cause drowsiness and lack of coordination. It is used in solvents and pesticides.

personnel and floating units were detailed to maintain surveillance of the damaged and burning barges and shore facilities as well as the oil pollution and to make reports to the command center. Personnel in the command center maintained annotated maps and status boards to provide a current graphic display of the location and condition of damaged barges and facilities and the extent of the pollution. Early in the emergency, the Captain of the Port requested the services of the Coast Guard's Gulf Strike Team, based in Bay St. Louis, Louisiana, and the team arrived in St. Louis the next day to clean up the oil if required to do so. The Captain of the Port also made immediate contact with Valley Towing Service, Inc., regarding the accident and responsibility for cleaning up the oil. Valley Towing Service, Inc., acknowledged responsibility and had a contractor on scene the next day to commence cleaning up the oil. Members of the Gulf Strike Team established close contact with the clean-up contractor in order to render continuous technical advice on such matters as the placement of containment booms and oil removal equipment. During the first few days, the Coast Guard conducted helicopter flights in order to keep track of the pollution which continued to extend farther downstream.

Personnel in the Office of the Captain of the Port reported that the Local Oil Pollution and Hazardous Material Contingency Plan proved to be workable and appropriate to handling the demands of this accident. No indication of any problem areas regarding the Coast Guard's response to this emergency were identified during the investigation, although Coast Guard personnel did acknowledge that they anticipated some backlog in their routine work, such as inspections, due to being temporarily detailed to duties involving the accident.

Injuries to Persons

<u>Injuries</u>	<u>Crew</u>	<u>Other</u>	<u>Total</u>
Minor	0	1	1
None	10	0	10
Total	10	1	11

Vessel Damage

The towboat CITY OF GREENVILLE was undamaged; however, all four barges in the tow were damaged. The lead barge (V882) was severely holed in the forward tanks. The second barge (V883) was holed and sustained considerable structural damage, and was a constructive total loss. Both of these barges were engulfed in fire which burned off the paint and destroyed mooring lines and cargo hoses stowed on deck. The third barge (V884) was extensively damaged by the collision and by an explosion. It sank about 1 mile downstream from the Poplar Street Bridge, and subsequently was raised by using barge-mounted cranes and a large catamaran salvage vessel positioned over the barge. Most of the starboard side of barge V884 was heavily distorted, and the force of the explosion blew off hatches and butterworth covers of the No. 1 port and starboard and the No. 2 port and starboard tanks. These four tanks had been ripped open and were severely distorted. This barge was a constructive total loss. The last barge in the tow (V885) sustained damage to its plating and framing. The total damage to the tow and its cargo was estimated to be about \$1.5 million.

Other Damage

Numerous fires were ignited along approximately 2 miles of the Illinois side of the river. Monsanto estimated that its barge unloading facility sustained \$3 million in damage, and Pillsbury estimated that \$2 million will be required to rehabilitate the grain

conveyor and mooring facilities at its grain loading facility. Approximately 23 barges, including loaded grain barges, freight barges, and tank barges, were damaged or were set on fire. The cost of cleaning up the spilled oil was \$550,000. The total damage to waterfront facilities, including moored barges and their cargos, was estimated to be about \$7.5 million.

Crew Information

The CITY OF GREENVILLE was manned by a crew of 10, including 3 licensed towing vessel operators referred to herein as the operator, the relief operator, and the steersman. The operator and relief operator shared navigational responsibility on a 6-hour alternating watch system; the operator stood the 6-12 watches and the relief operator stood the 12-6 watches. The steersman, who was a licensed operator, was on board in a training status to become familiar with the waterway and with the operation of the towboat.

The operator, age 56, had held a license as operator of uninspected towing vessels on the Western Rivers and Inland Waters since 1973. ^{9/} He had been employed as a relief operator and operator of towboats since 1961 and had been employed by Valley Towing Service, Inc., as operator of the CITY OF GREENVILLE since 1974. He had made one trip downbound through St. Louis harbor on the CITY OF GREENVILLE pushing the same tow in an empty condition during daylight in January 1983 and one trip downbound with the tow in a loaded condition during daylight about 5 days prior to the accident, when the river stage was about 22 feet on the St. Louis gage and the current velocity was considerably lower than at the time of the accident. Previous to these transits he had not piloted a tow through St. Louis harbor in the past 12 years. The operator testified that he had been involved in one collision, in 1973, when another tow struck his tow in the side, but damage was slight and no one was injured. He stated that he had never collided with any bridge prior to the accident.

The operator testified that he had not gone ashore at any time while the tow was loading in Wood River. He said that he followed his usual routine of resting between watches, obtaining most of his rest between midnight and 0600, augmented by a brief nap in the afternoon. He testified that he was in good health, had good vision, and was not taking any medication.

The relief operator, age 30, took command of the CITY OF GREENVILLE whenever the regular operator was on leave. He had held a license as operator of uninspected towing vessels since 1973. He had been employed by Valley Towing Service, Inc., since January 1981 and had been permanently assigned to the CITY OF GREENVILLE for about 3 months at the time of the accident; he had previously served on the CITY OF GREENVILLE for about 6 months in 1981. He had made about 12 trips as a relief operator through St. Louis harbor in various low and high water conditions over the past 9 years. He stated that his operating experience during high water conditions included operation during river stages up to about 15 feet.

Vessel Information

The CITY OF GREENVILLE was a conventional, uninspected, diesel-driven, push-type towboat, built in 1958. It was owned and operated by Valley Towing Service, Inc., of Memphis, Tennessee. The CITY OF GREENVILLE was equipped with the

^{9/} The Towing Vessel Licensing Act of 1972 required operators of towing vessels, 26 feet or more in length, to be licensed by the Coast Guard commencing September 1, 1973.

navigation and communication devices normally found on towboats, including radar and radiotelephone equipment, and full control of the engines was accomplished in the pilothouse. The vessel was equipped with twin screws, twin rudders, and flanking rudders. All equipment on board was operating properly at the time of the accident. The towboat's principal characteristics were:

Length	110 feet
Beam	30 feet
Depth	8.6 feet
Gross Tons	372
Horsepower	3,200

The four tank barges being pushed by the CITY OF GREENVILLE comprised a unit tow. ^{10/} The barges were of single-hull construction, so the entire hull of each barge, less voids at each end, constituted the cargo tank section of the barge. A longitudinal bulkhead divided the tank section into port and starboard tanks, and transverse bulkheads separated the bow and stern sections from the cargo tank section and also subdivided the cargo tank section into smaller tanks to provide compartmentation and stability. Each barge was inspected by the Coast Guard and certified for the carriage of grade "B" Liquids. ^{11/} The principal characteristics of each barge (listed from lead to trail barge) are as follows:

	<u>V882</u>	<u>V883</u>	<u>V884</u>	<u>V885</u>
Length (feet)	265	280	150	240
Breadth (feet)	50	50	50	50
Depth (feet)	12	12	12	12
Normal operating draft (feet)	9	9	9	9
Gross tons	1,377	1,593	761	1,275
Capacity (bbl)	23,200	28,380	14,800	21,000
No. of cargo tanks	8	10	6	8

Waterway Information

The accident occurred in a section of the Upper Mississippi River opposite metropolitan St. Louis, Missouri, at the Poplar Street Bridge, a principal artery for highway traffic between St. Louis, Missouri, and East St. Louis, Illinois. This section of the river is about 1,400 feet wide and follows a gradual downriver bend to the right. On the Missouri side of the river, moorings for excursion boats and floating restaurants are located upstream of the Poplar Street Bridge, and barge mooring areas and extensive industrial facilities are located downstream of the bridge. A number of industrial facilities are located along the Illinois side of the river, including the Peabody Coal Company terminal located immediately upstream of the Poplar Street Bridge, and extensive barge mooring areas and several barge terminals located below the Poplar

^{10/} A unit tow consists of barges designed so that the lead barge has a rake at the bow to minimize water resistance and a square stern for joining with the square end of another barge to eliminate any underwater surface break and thus reduce water resistance. The trailing barge has a square bow and a short rake at the stern. Barges inserted between the lead and trailing barges have square ends.

^{11/} Grade B flammable liquids are those having a Reid vapor pressure of more than 8 1/2 psi and less than 14 psi and a flashpoint of 80° F or lower. Most commercial gasolines are grade B liquids. Grade C flammable liquids which have a lower hazard rating, are those having a Reid vapor pressure of 8 1/2 psi or less and a flashpoint of 80° F or lower. Most crude oils are grade C liquids.

Street and Douglas MacArthur Bridges. These terminals include, among others, the Monsanto Chemical Company's barge off-loading facility and the Pillsbury Company's grain barge loading facility.

The principal sources of navigation information available to mariners on the Upper Mississippi River are the navigation charts published by the Corps of Engineers and the Light List published by the Coast Guard. The navigation charts, which were last updated in 1982, are contained in a single spiral-bound booklet. Each sequential chart covers a little more than 5 miles of waterway. Like the previous edition, effective use is made of colors to identify appropriate features of the waterway. Tables were added in the 1982 version to identify prominent facilities along the waterway. The horizontal and vertical clearances provided in the navigation spans are listed on the charts adjacent to each bridge. Unlike some other navigation charts prepared by the Corps of Engineers, the charts for the Upper Mississippi River do not show profile drawings of the bridges crossing the waterway; thus, the charts do not enable a mariner to determine readily the precise number and location of bridge piers, or the configuration of a bridge. The Light List provides a comprehensive list of all lighted aids to navigation and appropriate descriptive remarks. The Light List also gives the location of each bridge and lists the horizontal and vertical clearances of the navigation spans. Vertical clearances for bridges in the St. Louis area are measured either above the 2 percent line 12/ or above the zero elevation on the St. Louis gage. Mariners are informed of changes occurring to the aids to navigation by local notices to mariners published by the Coast Guard, and any important changes in the aids are broadcast by the Coast Guard using Coast Guard radio stations.

The principal navigation openings in the Eads, Poplar Street, and Douglas MacArthur Bridges are located in the main spans in the center of the river. The Eads Bridge consists of three steel arches. The center or main arch is somewhat larger than the two side arches and provides 517 feet of horizontal clearance between the supporting bridge piers under normal water conditions, according to the U.S. Coast Guard publication CG-425-2, Bridges Over Navigable Waters of the United States. However, the high water conditions at the time of the accident had reduced the vertical clearance under the side portions of the arch so that only about 300 feet of horizontal clearance in the center of the span was actually usable for navigation. The Poplar Street Bridge is of continuous steel girder construction and provides a flat arch over each navigation span; the vertical clearance was sufficient to permit the CITY OF GREENVILLE to pass underneath any portion of the bridge. The Douglas MacArthur and the Veterans Memorial Bridges are of through truss construction and provide a uniform vertical clearance in each navigation span. The Poplar Street Bridge normally provides 580 feet of horizontal clearance during high water. The main span of the Douglas MacArthur Bridge provides 657 feet of horizontal clearance. Horizontal clearance available in the side span of the Poplar Street bridge was listed as 480 feet in CG-425-2; however, the location of mooring cells 13/ of the Peabody Coal Company terminal, reduced the actual clearance to approximately 420 feet. There were no barges moored at the Peabody Coal Company terminal, which would have reduced the horizontal clearance, but there were barges moored along the Illinois side of the river immediately downriver from the Poplar Street Bridge, and these would have further reduced the clearance available in the side span by about 50 feet.

12/ The high water level that is exceeded only 2 percent of the time. In the St. Louis area this is about 30.5 feet on the St. Louis gage.

13/ Cells used for moorings and as protective fenders are fabricated from sheet piles interlocked into cylinders about 15 to 30 feet in diameter. The sheet piles are driven into the bottom, and each vertical cylinder is filled with sand, gravel, or rock, and the top is covered with a thin layer of concrete. Steel piles usually are driven in the inside of the vertical cylinders to increase resistance to impact.

According to the U.S. Army Corps of Engineers St. Louis District, the river stage was 29 feet on the St. Louis gage and rising at the time of the accident. Flood stage is 30 feet. The river crested at 36.4 feet on April 10 and at 38.3 feet on May 5, 1983. The surface current at the 29-foot stage was about 6 to 7 mph in the center of the river. Lesser velocities usually occur along the banks of the river in this area.

At the request of the Safety Board for data on the river bottom, the Corps of Engineers on April 5, 1983, dispatched its survey vessel, the M/V PATHFINDER, to take soundings near the Eads and Veterans Memorial Bridges to ascertain if there were any changes in the bottom as a result of the high water conditions that might have caused unusual current conditions at these bridges. Bottom conditions were found to be unchanged. The operator of the PATHFINDER reported that his vessel encountered a slight crosscurrent near the Veterans Memorial Bridge which set his vessel to the left toward Illinois. He stated that his vessel was drawing about 5 feet of water and that a tow drawing 9 feet might experience a greater effect from the current. The operator also reported that, after taking the requested soundings, he had stopped his vessel under the center span of the Eads Bridge and allowed the vessel to float downstream with the current toward the Poplar Street Bridge. He reported that on the basis of the position of the PATHFINDER after it had drifted about one half the distance to the Poplar Street Bridge, he believed the vessel would have passed through the center portion of its main span. He said that there were no indications of any crosscurrents in the center of the river between the Eads and Poplar Street Bridges.

Interviews with three veteran towboat operators^{14/} revealed that high water conditions (20 feet and greater on the St. Louis gage) will produce a crosscurrent in the vicinity of the Eads Bridge that will cause a tow to set to the left toward the left descending pier of the main span. Each operator stated that when passing beneath the bridge, it was necessary to position the tow to the right of the sailing line, which is shown on the Corps of Engineers charts, in order to compensate for this set. They estimated that an offset at somewhat greater than 100 feet to the right of channel axis should be achieved when a downbound tow is about 1/4 mile upriver from the Eads Bridge. All operators interviewed stated that they would not recommend navigation through the left side span of the Poplar Street Bridge by downbound tows during high water.

The relief operator of the CITY OF GREENVILLE, who had entered the pilothouse about 2310 when the tow was about 3/4 mile above the Eads Bridge, testified that he did not pay particular attention to what maneuvers the operator was conducting to bring the tow under the bridges until a short time before the collision, but he did recall that the tow was set to the left as it passed under the Eads Bridge. He stated that shortly before it became evident that a collision situation was developing, he noticed that the operator was attempting to pass through the left side span of the Poplar Street Bridge. He stated that he had navigated tows through the left side span of the bridge before, but that when he had done so, he also had navigated the tows first through the left side span of the Eads Bridge. He also stated that these maneuvers had been made during periods of low water.

Until about 1980, the Coast Guard required the owners of most bridges on the Western Rivers to use retroreflective material in conjunction with navigation aids on their bridges. Illumination of this material by a vessel's searchlight produces a brilliant, readily detectable reflection. A question regarding the legal authority provided by the bridge statutes to require this material led the Coast Guard to abandon this requirement. The

^{14/} One was a member of the Towing Safety Advisory Committee, which advises the U.S. Department of Transportation on matters affecting the towing industry, and two were members of the River Industry Action Committee, a private group representing the collective navigational interests of the towing industry operating in the St. Louis area.

Coast Guard subsequently determined that the bridge statutes do provide sufficient authority to require the installation of retroreflective material on bridges for navigation purposes, and has initiated a program to prepare regulations that will reestablish this requirement.

Environmental Information

At the time of the accident the sky was cloudy and there was occasional light rain. The wind was from the northwest, at about 15 mph, with occasional gusting to 25 mph. The temperature was 38° F. Visibility was about 8 miles.

Medical and Pathological Information

One person working on board one of the chemical barges at the Monsanto pier sustained mild chemical burns on his face from the monochlorobenzene that was released.

Other Information

The Towing Vessel Licensing Act of July 7, 1972, requires that all commercial vessels of 26 feet or more in length engaged in or intended to engage in the service of towing be under the actual direction and control of persons licensed by the Coast Guard. Prior to 1972 there were no requirements that operators of diesel-powered towboats be licensed. The Act gives the Coast Guard authority to limit the scope of an operator's license to specified geographical areas or to a limited route. Initially, the Coast Guard adopted a policy of not restricting licenses, particularly those issued to operators who were already engaged in piloting towing vessels. In this regard the Coast Guard guidance issued in its Navigation and Vessel Inspection Circular No. 3-74, dated March 25, 1974, stated:

The regulations retain the traditional authority of the OCMI [15/] to limit any license issued by him commensurate with the experience of the applicant (46 CFR 10.16-11(b) and 10.16-41(g)). However, in authorizing routes, it is desired that a liberal policy be followed, particularly during the initial period of licensing persons under the "Grandfather clause" provisions. Generally, the "Grandfather clause" applicant who presents the necessary letter of service and can pass the Rules of the Road Examination with no problem and no concession from the examining officer should be given the entire broad geographical area in which his experience has been obtained. For the applicant who has trouble passing the Rules of the Road examination and who requires an oral examination, the OCMI may use his discretion in imposing a suitable restriction which will allow the applicant to continue his present employment on towing vessels in the local area with which he is intimately familiar. In imposing such a restriction, the OCMI may modify the standard examination as he sees fit. The limited route granted should lie wholly within his inspection zone unless he obtains agreement from other affected OCMI's to extend the route beyond his zone. It is expected that such limited routes will be the exception and that the majority of candidates will qualify for the entire broad areas identified in the regulations.

The policy of granting an operator authority to operate a tow throughout the Western Rivers, even though his experience may extend to only a portion of the Western Rivers, continues in effect. An example is the case of the steersman, who was employed

15/ U.S. Coast Guard Officer in Charge of Marine Inspection for a particular zone.

by Valley Towing Services, Inc., on board the CITY OF GREENVILLE to gain experience before being entrusted by that company with the responsibility of piloting a tow through the Upper Mississippi River. The steersman had acquired a license from the Coast Guard and was legally authorized to operate a tow anywhere in the Western Rivers.

The license examination currently administered by the Coast Guard for operators of uninspected towing vessels on the Western Rivers covers the following areas:

1. Rules of the road
2. Operation and use of navigation instruments
3. Emergency signals
4. Practical use of charts
5. Aids to navigation
6. Lifesaving and simple first aid
7. Firefighting equipment and procedures and fire prevention
8. Boatmanship for the Western Rivers
9. Regulations and laws applicable to towing vessel
10. Pollution prevention

There are no requirements for testing an applicant's knowledge of the waterway or any portion of the waterway that he may operate on.

ANALYSIS

The Accident

The operator testified that he was aware that a draft, or crosscurrent, could exist near the Eads Bridge, but that he did not know from which direction it might come. The investigation revealed that it is common knowledge among operators familiar with the St. Louis area that high water conditions will produce a crosscurrent that will set a tow toward the left descending side of the bridge's center span opening, and that for a successful transit it is essential for a downbound tow to be to the right of the centerline of the span as it approaches the Eads Bridge in order to compensate for a set to the left. A lack of knowledge of conditions at the Eads Bridge resulted in the operator aligning his tow with the center of the bridge span rather than being offset to the right of the sailing line. As the tow passed beneath the bridge, it was set to the left, necessitating the use of left rudder to move the stern of the tow to the right to prevent the pilothouse or other structure of the towboat from colliding with the low steel of the left side of the arch. The use of left rudder caused the tow to point toward the Illinois shore at a sharper angle than is normally adopted by downbound tows, so that the tow was pointing toward the Peabody Coal Terminal rather than in the general direction of the left side span of the Poplar Street Bridge. The tow's sharp angle toward the Illinois shore and the operator's concern for possible collision with the low steel of the left portion of the center arch of the Eads Bridge may have caused the operator to become disoriented momentarily and to fail to recognize that it was essential to direct the head of the tow back to the right as soon as the tow cleared the Eads Bridge. The operator testified that the curve of the river to the right would cause the tow to point to some extent toward the Illinois side of the river as the tow passed under the Eads Bridge. However, on the night of the accident, the operator failed to consider the shape of the river, and he began to steer straight toward some green lights that appeared ahead of the tow after he passed under the Eads Bridge.

The operator failed to recognize or take into consideration at this critical time, probably because of a lack of familiarity with navigating in the area, that the Poplar Street Bridge had more than one navigation span and that the preferred span, providing

the most horizontal clearance, normally would be lighted with three white lights in a vertical line above the green lights. In addition to providing greater horizontal clearance, the main span of the Poplar Street Bridge was located in the center of the river and was aligned with the center span of the Eads Bridge; thus, a vessel passing through the center span of the Eads Bridge could transit the main span of the Poplar Street Bridge with little transverse adjustment across the current.

The straight course that the operator steered toward the left side span of the Poplar Street Bridge resulted in a diagonal trackline across the river from a position near the center of the river toward a point on the left side of the river. The tow was, in fact, crabbing ^{16/} since it was cutting across the current of the river. As the tow proceeded downriver, it would have been necessary to bring the head of the tow to the left in order to continue to head toward the green lights of the side span, thus increasing the tow's angle to the current. The operator probably failed to recognize that the tow was crabbing, since he initially believed that he was steering for the main span in the center of the river. It is possible that the progress of the tow also could have been affected by the occurrence of a crosscurrent from the Illinois side of the river at some point below the Eads Bridge and above the Poplar Street Bridge. A crosscurrent would have required the operator to compensate by steering further to the left, which would account for a portion of the tow's relatively steep angle toward the Illinois shore at the time of impact.

Shortly before the tow struck the bridge pier, the head of the tow had moved under the side span, but the stern of the tow, due to the angle on the tow, was to the right of the bridge pier. In an attempt to move the stern of the tow to the left to clear the pier, the operator applied full right rudder; however, this action was not successful and probably served only to move the point of collision farther aft to about the location of the midpoint of the tow. The ineffectiveness of this maneuver could have been due to a crosscurrent from the Illinois side of the river but more likely was due to the effect of higher velocity current acting more on the stern than on the bow, i.e., since the tow was at a relatively steep angle toward the Illinois shore at the time of the collision, the stern was protruding farther toward the center of the river where the river flowed at a greater velocity than nearer to the shore where the bow of the tow was. Thus, the tow probably was experiencing a coupling effect which was tending to rotate the tow's heading to the left and the stern to the right nullifying the effect of the full right rudder. The Safety Board believes that the operator never succeeded in centering the tow on or near the centerline of the side span and that the tow probably was never aligned properly for passage through the span.

The operator demonstrated that he was not well informed about how to navigate a large tow through the St. Louis area at night during high water conditions. He did not know the direction of the crosscurrent normally found at the Eads Bridge during high water; thus, he was unable to position his tow during the approach to the bridge in order to compensate for the crosscurrent and to prevent his towboat from being set close to the low steel of the left side of the main arch as he passed underneath. When the tow cleared the Eads Bridge, the operator did not see the three white lights over green lights which marked the center of the main span of the Poplar Street Bridge, as he expected, but he decided to head for the green lights he did see on the assumption that the white lights were extinguished. In fact, these green lights mark the center of the side span. If the operator had possessed adequate local knowledge, he would have been aware of three crucial factors: (1) that the tow would be headed in the general direction of the Illinois side span as the towboat exited the center span of the Eads Bridge, (2) that it is not a recommended practice for large downbound tows to use the Illinois side span during

^{16/} To drift sidewise as a result of current or wind.

high water conditions, and (3) that it was essential to direct the head of the tow to the right after clearing the Eads Bridge, due to the curvature of the river, in order to head for the main span of the Poplar Street Bridge located in the center of the river. The sailing line shown on the Corps of Engineers chart for the St. Louis area, which passes through the center of the bridges, is nearly in the center of the river; thus the operator could have ascertained ahead of time that he should keep his tow near the center of the river. The Safety Board believes that an operator piloting a large tow through the St. Louis area must have sufficient local knowledge that he can locate the main spans of all bridges and navigate safely through them without regard to whether the navigation lights marking the center of each main span are illuminated, and that the operator must have a similar high level of local knowledge of all other areas along his route which may be difficult to navigate.

In this case the accident might have been avoided if the operator had recognized that he was getting into a difficult situation and had requested the assistance of the relief operator to locate the main span of the Poplar Street Bridge. If the relief operator had been carefully following the progress of the tow, he could have recognized that the operator was erroneously heading toward the side span and informed the operator of the location of the main span. The relief operator had recent experience in piloting other towing vessels through the area, but at river stages up to only 15 feet. He should have anticipated that the transit of the bridges in the area could entail some crosscurrents and other unusual navigation problems since the river stage was above 29 feet--nearly at flood stage--with very high velocity current conditions, and that these conditions could affect the progress of the tow at any time, requiring extensive maneuvering to maintain control of the tow. The Safety Board believes that these circumstances which the relief operator had not experienced should have made him more attentive to the progress of the tow especially since he was waiting to relieve the operator. If he had been more attentive, he easily could have recognized that the operator had not directed the head of the tow to the right immediately after passing under the Eads Bridge and he could have assisted the operator in locating the main span of the Poplar Street Bridge.

Bridge Navigation Information

The operator did not notice the white lights above the green lights marking the center of the main navigation span until the tow was about midway between the Eads and Poplar Street Bridges. Although one of the three lights was not illuminated, the Safety Board does not consider that the missing light was a causal factor in this accident. The operator testified that he thought that the span that he was heading for might be the main navigation span, even though it was marked only by green lights. He said that the white lights might be burned out, which he said happened occasionally on other bridges. The lack of white lights did not dissuade him from attempting to use this span or cause him to recognize that he could be heading away from the main span. Since the tow was heading diagonally across the river, the operator should have recognized that he was not heading for the center of the Poplar Street Bridge, but toward the left side, and he should have realized that the green lights could be confirming that he was heading toward a side or alternate span. Visibility in the vicinity of the main span may have been affected briefly by the occasional light rain, but concerted attempts to see the white lights by looking along the entire bridge probably would have resulted in the operator's locating them in sufficient time to successfully maneuver the tow through the main navigation span. The main span was well marked with green lights in the center of the span under the two white lights, and the piers on either side were marked with red lights.

In this case it appears that the operator did not know where the main span of the Poplar Street Bridge was located until he finally saw the two white lights. The operator

could have used the searchlight effectively to locate the bridge piers on either side of the main navigation span, if he had recognized that he might not be headed in the right direction and if he had been familiar with the configuration of the bridge. Retro-reflective material near the navigation lights could have been beneficial since it would have produced a reflection when illuminated by the searchlight of a towboat that is considerably more brilliant than the bridge navigation lights. Retroreflective material near the lights marking the center of the main span would enable an operator to locate the main span by sweeping the length of the bridge until the material was illuminated. The Safety Board believes that the Coast Guard should give a high priority to reinstituting the use of retroreflective material to supplement navigation lights on bridges over navigable waters.

Also, it appears that measures could be taken to make navigation spans of bridges more prominent and easier to identify. This could be accomplished by augmenting or modifying existing bridge lighting. The Safety Board believes that the Coast Guard should study means to enhance the mariner's ability to identify lights marking the navigation spans of bridges where such lights may be difficult to detect due to interference from other lights or due to impaired visibility or where it is essential that the mariner locate a span quickly.

Navigation charts prepared by the Corps of Engineers for many waterways, including portions of the Western Rivers, contain profile drawings of bridges crossing the waterways which enable the mariner to ascertain readily the general configuration of the bridge, the location of the navigation openings, and the location of the various bridge piers. Since the charts for the Upper Mississippi River do not contain such profile drawings, a mariner who is unfamiliar with the area can only formulate an estimate of the number and location of the piers based upon the sailing line appearing on the chart, which normally passes through the center of the main span, and the clearances for the navigation spans found either on the charts or in the Light List. The Safety Board believes that an estimate based upon such limited data is not an adequate substitute for a profile drawing, and that the Corps of Engineers should insure that all the river navigation charts it publishes in the future include profile drawings of all bridges. The profiles should show the river mile, clearance data, and include appropriate annotations to aid the mariner.

Navigation Information

Valley Towing Service, Inc., entrusted the operation of the CITY OF GREENVILLE to a veteran operator who had a good safety record and to a relief operator who had recent experience in the St. Louis area. The company has recognized the need for its navigating personnel to have experience on the routes to which assigned and to this end assigned a licensed operator to the CITY OF GREENVILLE as a steersman to acquire local experience prior to his being entrusted with operation of a towing vessel in this portion of the Western Rivers.

In the towing industry it is not unusual for a company to enter a contract which requires it to operate on portions of the extensive Western Rivers navigation system that are not familiar, or recently familiar, to the operators piloting the company's vessels. Unfortunately, this accident demonstrates that some degree of familiarity with local conditions is important and sometimes crucial even for the most experienced and capable operator. However, there is no reference source for an operator to consult in order to obtain information on such phenomena as crosscurrents that may occur at some bridges, locks, channel bends, and other such sites in the Western Rivers. The Safety Board

believes that the acquisition, accumulation, and publishing of such data in a format similar to the United States Coast Pilot 17/ is warranted. Such a publication could be especially helpful to operators with limited local experience.

The Corps of Engineers regularly is involved in maintaining the navigable waters of the United States and is the repository of extensive data on commercial waterways. Furthermore, through the operation of its vessels, contacts with other government agencies, and the management of contracts, the Corps of Engineers has access to a wide range of data on changing conditions of the nation's waterways. Accordingly, the Safety Board believes that the Corps of Engineers should develop and publish a guide providing navigation information on the Western Rivers. Such a guide could provide information on landmarks used by mariners in navigating various difficult areas and about the proven maneuvers used by mariners to compensate for current or winds during different river stages of the waterway and during different seasons.

Licensing

The practice followed by the Coast Guard of licensing operators of towing vessels to operate anywhere on the Western Rivers regardless of their past experience may have been a necessary procedure when the Towing Vessel Licensing Act of 1972 was first implemented. However, the granting of the right to operate throughout the Western Rivers, without requiring that an applicant for a license be examined on his knowledge of the area in which he will operate does not provide an adequate safeguard to prevent accidents like this particular one. The degree of qualification achieved by newly licensed operators depends to a large extent upon whether the particular towing company has a steersman training program, as did Valley Towing Service, Inc., and the quality of instruction that the operator can impart to the steersman. It would be preferable that an operator be required to demonstrate to the Coast Guard that he has local knowledge of the routes for which he seeks to be licensed. The testing procedures for knowledge of a particular route would not need to be as rigorous as that required for a first-class pilot's license, such as being able to sketch the entire route that the license is to cover. In the case of a license as operator of uninspected towing vessels on the Western Rivers, it would suffice if the applicant were tested on specific critical areas, such as the St. Louis area and other similar metropolitan areas, certain bends, and areas where current or other conditions severely affect the safety of navigation. The Coast Guard should identify critical areas of the Western Rivers and require that an applicant for a license as an operator of uninspected towing vessels be examined for local knowledge of any of these critical areas covered by the license.

CONCLUSIONS

Findings

1. If the operator had been more familiar with the St. Louis area, he would have been able to locate the main span of the Poplar Street Bridge quickly, and he might have successfully navigated the tow through the bridge without difficulty.

17/ A series of publications, published by the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, giving peculiarities of, and necessary information for, navigating the coastal waters, Great Lakes, and ports of the United States.

2. If the operator had known that he might encounter a draft, or crosscurrent, upstream of the Eads Bridge setting toward the Illinois side of the river, he could have positioned the tow to compensate for the effects of the current and avoided having his tow set close to the low steel of the left side of the arch and averted the need for a maneuver which resulted in aligning the tow at a sharp angle toward the Illinois side of the river.
3. The accident might have been avoided if the operator had recognized that it was essential to direct the head of the tow back to the right as soon as the tow cleared the Eads Bridge in order to steer for the main navigation span of the Poplar Street Bridge.
4. If the operator had been more familiar with the St. Louis area, he probably would not have attempted to navigate his downbound tow through the Illinois side span of the Poplar Street Bridge.
5. The accident might have been avoided if the relief operator, who was familiar with the area, had been paying closer attention to the tow's maneuvers, since he might have been able to alert the operator to the location of the main navigation span at the Poplar Street Bridge in time to align the tow for a safe passage through the bridge.
6. The fact that one of the three lights in the vertical line of three white lights above the green lights marking the center of the main navigation span of the Poplar Street Bridge was burned out was not a factor in this accident.
7. If navigation information in a ready reference format similar to the Coast Pilot had been available and used by the operator, he might have learned of the nature of the crosscurrent during high water conditions at the Eads Bridge. He also might have ascertained better the relative location of the piers and spans of the Poplar Street Bridge, which would have enabled him to be prepared to safely transit St. Louis harbor during high water.
8. Retroreflective material should be used to augment navigation lights on bridges, where conditions may make the navigation lights difficult to detect.
9. It may be feasible to use auxiliary lighting to enhance ready identification of the main spans of bridges where background lights or other conditions make the prescribed navigation lights difficult to detect.
10. The ability of newly licensed operators of uninspected towing vessels to pilot vessels safely through the extensive Western Rivers depends largely upon whether the towing company employer has an underway training program and the quality of instruction that the company's experienced operators can provide.
11. Including questions about areas that are difficult to navigate in the license examinations for operators of uninspected towing vessels could insure more widespread knowledge of how to navigate through these areas.
12. Adding profile drawings of bridges to the Upper Mississippi River navigation charts would enable mariners to determine more readily the configuration of each bridge and the number and location of bridge piers.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the operator of the towboat CITY OF GREENVILLE to identify the main navigation span of the Poplar Street Bridge in time to align his tow for passage through the span.

RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board recommended that:

--the U.S. Coast Guard:

Identify critical areas of the Western Rivers which are difficult to navigate due to unusual current conditions, sharp bends, navigation clearance restrictions, or similar circumstances, and require future applicants for licenses as operators of uninspected towing vessels to take an examination regarding local knowledge of these areas. (Class II, Priority Action) (M-83-93)

Expedite the promulgation of regulations to require installation of retroreflective material on bridges to supplement navigation lights. (Class II, Priority Action) (M-83-94)

Study the use of auxiliary lighting to enhance the mariner's ability to identify lights marking the navigation spans of bridges where such lights may be difficult to detect due to interference from other lights or due to impaired visibility or where it is essential that the mariner locate a span quickly. (Class II, Priority Action) (M-83-95)

--the U. S. Army Corps of Engineers:

Develop and publish a navigation guide or guides for mariners navigating the Western Rivers similar in format to the United States Coast Pilot. (Class II, Priority Action) (M-83-96)

Include profile drawings of all bridges in the next revision of the Upper Mississippi River Navigation Charts. (Class II, Priority Action) (M-83-97)

--Valley Towing Service, Inc.:

Formalize existing qualification procedures to insure that operators piloting your towing vessels have sufficient experience and knowledge regarding all areas of their assigned routes to navigate safely in all prevailing waterway conditions. (Class II, Priority Action) (M-83-98)

—the American Waterways Operators, Inc.:

Publish an article in your newsletter informing your members of the circumstances of the accident in St. Louis, Missouri, on April 2, 1983, and of the benefits of having formal qualification procedures to insure that operators piloting towing vessels have sufficient experience and knowledge regarding all areas of their assigned routes to navigate safely in all prevailing waterway conditions. (Class II, Priority Action) (M-83-99)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ PATRICIA A. GOLDMAN
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ G. H. PATRICK BURSLEY
Member

/s/ DONALD D. ENGEN
Member

November 29, 1983